QUANTIFYING THE DURATION OF UNDERSTORY NUTRIENT CHANGES FOLLOWING PRESCRIBED BURNING IN PONDEROSA PINE

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FINAL REPORT

for

Quantifying the duration of understory nutrient changes following prescribed burning in ponderosa pine

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by

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INTRODUCTION

This study was designed to determine the relationship between time since prescribed burning and nutrient concentration in important forage plants in ponderosa pine (*Pinus ponderosa* Laws) forest on basalt soils in northern Arizona.

The nutritive quality of forage plants is of utmost importance in determining reproductive success, weight gain, mortality, and carrying capacity of both wildlife and livestock. While some information is available about the effects of wildlife on improvement of wildlife habitat (Kruse, 1972, Campbell et al. 1977, Lowe et al. 1978) and forage quality (Pearson et al. 1972), very little data is available on the effects of prescribed burning on the quantity and quality of understory vegetation.

Previous research funded by the Eisenhower Consortium (EC-222) and by the Rocky Mountain Forest and Range Experiment Station (Fuel Management Project 2108) showed that an experimental prescribed understory burn in uncut ponderosa pine greatly increased nutrient availability (Ryan and Covington in review, Covington and Sackett in review). Subsequent research at the same study area showed increases in understory vegetation standing crop and nutrient concentration (Harris and Covington in press). However, no information is available regarding effects of larger management prescribed burns nor long-term effects.

The object of this research was to determine the duration of changes in nutrient concentrations in understory vegetation following prescribed burning in ponderosa pine on basaltic soils in northern Arizona. The approach was to sample understory vegetation for nutrient analysis from different aged burns.

Since spatial variation in understory nutrient concentrations was unknown, each burn site was paired with a nearby control. Nutrients analyzed included Ca, Mg, K, N, and P.

METHODS

A time sequence ranging from one to six years (growing seasons), with adjacent controls, was established in ponderosa pine in northern Arizona. Insofar as possible, sites were selected to be similar in every respect (e.g., soil type, elevation, slope, aspect, etc.) except time since burning.

Since overstory conditions influence both fuel reduction and understory vegetation response (Covington and Sackett in review, Harris and Covington in press) and since wildlife and livestock preferentially utilize more open areas, sampling was restricted to open sawtimber stands dominated by trees greater than 28 cm DBH.

Random sampling was conducted when each species was on a physiologic plateau (e.g., just after flowering) to minimize phenologic effects on variability in nutrient concentration. For each species present, five composite samples consisting of six subsamples each were collected. Only current year's growth was collected. Samples were returned to the laboratory, dried (80 C, 24 h), ground, digested, (Parkinson and Allen 1975) and analzed for cations (calcium, magnesium, and potassium) by atomic absorption spectroscopy and nitrogen and phosphorus using the Technicon AutoAnalyzer.

RESULTS AND DISCUSSION

Six prescribed burns were located which were similar in soil type (basaltic) and elevation (Table 1). Species collected included mountain muhly (Muhlenbergia

Table 1. Study site descriptions

Name of Prescribed Burn	Time Since Burning (yrs)	Elevation (m)	Location
79 Howard Seep	1	2320	T 24N R6E[1]
78 Elden	2	2225	T 21N R6E
77 Mint	3	2250	T 17 R9E
76 Hutch	4	2275	T 17N R9E
75 Walker	5	2280	T 22N R5E
74 Hostetter	6	2225	T 23N R7E

[1]Township and Range, Gila and Salt River Meridian

montana (Nutt.) Hitchc.), Arizona fescue (Festuca arizonica Vasey), squirrel tail (Sitanion longifolium J. G. Smith), muttongrass (Poa Fendleriana (Steud) Vasey), sedge (Carex spp.), and American vetch (Vicia americana Muhl.). However, not all species were present on some sites. The most complete data set is for squirrel tail where only the 4 yr control data are missing.

Analysis of variance of the control sites showed significant differences ($p = .05$) among controls for most nutrients, suggesting that geographical variation in nutrient concentrations is an important factor. Therefore, each burn was compared to its adjacent control, only.

The results of the nutrient analyses are presented in Tables 2-6. Although few differences were statistically significant ($p = .05$), the general trend for N, P, K, and Mg is one of higher concentrations for the first year after burning. Relative increases in N concentration were as much as 35% (for muttongrass) These increases, however, seem to be short-lived. By year 2 there is little difference for the two test species present and by year 3 and later significant differences are rare and there is no consistent pattern in direction of differences between burned and unburned plots.

Our results for the 1 yr old burn are in agreement with the observations of Harris and Covington (in press) for a nearby site, where N, P, and K were generally higher on a 1 yr old prescribed burn than on controls. Three years after the same burn Kogutt (personal communication) found that only mountain muhly still had significantly higher nutrient concentrations on burned sites. Similarly, Pearson et al. (1972) found that forage nutrient concentrations were higher the first season after a wildfire in ponderosa pine and that these increases disappeared by 3 years after burning.

Several mechanisms may explain the increased nutrient concentrations after

Table 2. Nitrogen concentration (%) for six understory species following prescribed burning in southwestern ponderosa pine. Data are mean/standard error, N=5 composites of 6 subsamples each. Significant differences between burn and unburned are: *=.05, **=.01, ***=.001

Time Since Burning (yr)	Mountain muhly	Arizona fescue	Squirrel tail	Sedge	Mutton-grass	Vetch
1	1.52/.103	2.18/.058**	2.26/.058***	1.88/.051	2.24/.188*	3.85/.161
Adajacent unburned	1.44/.025	1.74/.089	1.73/.073	1.88/.046	1.67/.145	- - -
2	1.18/.022	- - -	1.92/.106	- - -	- - -	- - -
Adjacent unburned	1.27/.059	- - -	1.82/.057	- - -	- - -	- - -
3	- - -	1.82/.102	1.81/.160	1.97/.072	1.67/.234	4.49/.174
Adjacent unburned	- - -	1.99/.066	1.89/.072	- - -	- - -	- - -
4	1.23/.023	1.89/.128	2.01/.105	1.91/.059	1.71/.132	4.44/.187
Adajacent unburned	- - -	- - -	- - -	2.02/.071	2.05/.209	4.45/.104
5	1.25/.059	1.67/.070	2.07/.077	1.93/.053	1.69/.133**	- - -
Adjacent unburned	- - -	1.67/.065	2.06/.148	1.97/.175	2.53/.149	- - -
6	1.35/.068	- - -	2.17/.058*	1.64/.024	1.69/.144	- - -
Adjacent unburned	1.37/.101	- - -	1.88/.089	- - -	1.64/.043	- - -

Table 3. Phosphorus concentration (%) for six understory species following prescribed burning in southwestern ponderosa pine. Data are mean/standard error, N=5 composites of 6 subsamples. Significant differences between burn and unburned are: *=.05, **=.01, ***=.001

Time Since Burning (yr)	Mountain muhly	Arizona fescue	Squirrel tail	Sedge	Mutton-grass	Vetch
1	.238/.0205*	.383/.0209**	.266/.0178**	.142/.0053	.201/.0122**	.243/.0149
Adjacent unburned	.186/.0053	.304/.0107	.212/.0092	.141/.0026	.277/.0153	- -
2	.155/.0061	- -	.217/.0192	- -	- -	- -
Adjacent unburned	.152/.0077	- -	.223/.0186	- -	- -	- -
3	- -	.276/.0199	.158/.0053	.123/.0034	.210/.0095	.231/.0091
Adjacent unburned	- -	.259/.0111	.156/.0089	- -	- -	- -
4	.161/.0034	.334/.0135	.199/.0100	.135/.0045	.327/.0086***	.257/.0127**
Adjacent unburned	- -	- -	- -	.118/.0061	.232/.0126	.202/.0060
5	.127/.0063	.222/.0179	.192/.0110**	.126/.0027	.281/.0161	- -
Adjacent unburned	- -	.258/.0130	.261/.0124	.124/.0043	.321/.0107	- -
6	.197/.0122	- - -	.228/.0157*	.121/.0023	.251/.0142	- - -
Adjacent unburned	.202/.0078	- - -	.180/.0031	- - -	.228/.0069	- - -

Table 4. Potassium concentration (%) for six understory species following prescribed burning in southwestern ponderosa pine. Data are mean/standard error, N=5 composites of 6 subsamples. Significant differences between burn and unburned are: *=.05, **=.01, ***=.001

Time Since Burning (yr)	Mountain muhly	Arizona fescue	Squirrel tail	Sedge	Mutton-grass	Vetch
1	.600/.0696	2.018/.0865	1.810/.0370*	1.672/.0679	1.862/.0655	2.203/.1916
Adjacent unburned	.539/.0394	1.795/.1079	1.590/.0598	1.615/.0460	1.653/.1342	- - -
2	.564/.0156	- - -	1.507/.0545*	- - -	- - -	- - -
Adjacent unburned	.545/.0078	- - -	1.742/.0717	- - -	- - -	- - -
3	- - -	1.866/.0471	1.655/.1058	1.623/.0369	1.769/.1017	1.929/.0678
Adjacent unburned	- - -	1.926/.0930	1.556/.1076	- - -	- - -	- - -
4	.622/.0332	2.030/.0713	1.714/.0369	1.732/.0521	1.771/.0373	2.291/.0990
Adjcent unburned	- - -	- - -	- - -	1.677/.0769	1.774/.0606	2.307/.1166
5	.729/.0454	1.606/.0626*	1.583/.0786*	1.773/.0355	1.659/.0830	- - -
Adjacent unburned	- - -	1.855/.0755	1.937/.1112	1.776/.0591	1.821/.0562	- - -
6	.545/.0124	- - -	1.848/.0786	1.470/.0173	1.687/.0732*	- - -
Adjacent unburned	.579/.0127	- - -	1.869/.0582	- - -	1.471/.0446	- - -

Table 5. Magnesium concentration (%) for six understory species following prescribed burning in southwestern ponderosa pine. Data are mean/standard error, N=5 composites of 6 subsamples. Significant differences between burn and unburned are: *=.05, **=.01, ***=.001

Time Since Burning (yr)	Mountain muhly	Arizona fescue	Squirrel tail	Sedge	Mutton-grass	Vetch
1	.179/.0290	.160/.0044	.176/.0076*	.144/.0033	.168/.0154	.535/.0540
Adjacent unburned	.165/.0172	.163/.0060	.155/.0048	.146/.0048	.143/.0120	- - -
2	.113/.0089	.122/.0029	.122/.0029*	- - -	- - -	- - -
Adjacent unburned	.129/.0037	- - -	.133/.0038	- - -	- - -	- - -
3	- - -	.127/.0080	.099/.0052***	.124/.0067	.103/.0084	.529/.0196
Adjacent unburned	- - -	.144/.0090	.140/.0064	- - -	- - -	- - -
4	.147/.0070	.150/.0146	.147/.0088	.162/.0036	.169/.0162	.499/.0438
Adjacent unburned	- - -	- - -	- - -	.149/.0094	.166/.0209	.543/.0227
5	.123/.0096	.135/.0116	.145/.0049	.104/.0022	.119/.0161	- - -
Adjacent unburned	- - -	.114/.0028	.134/.0077	.115/.0058	.133/.0047	- - -
6	.190/.0094	- - -	.177/.0140	.159/.0059	.171/.0116	- - -
Adjacent unburned	.168/.0061	- - -	.151/.0066	- - -	.149/.0053	- - -

Table 6. Clacium concentration (%) for six understory species following prescribed burning in southwestern ponderosa pine. Data are mean/standard error, N=5 composites of 6 subsamples. Significant differences between burn and unburned are: *=.05, **=.01, ***=.001

Time Since Burning (yr)	Mountain muhly	Arizona fescue	Squirrel tail	Sedge	Mutton-grass	Vetch
1	.424/.0739	.302/.0125	.387/.0161	.335/.0197	.401/.0278**	1.286/.1645
Adjacent unburned	.433/.0400	.330/.0160	.386/.0104	.358/.0210	.250/.0281	- - -
2	.351/.0159**	- - -	.409/.0174	- - -	- - -	- - -
Adjacent unburned	.440/.0141	- - -	.345/.0236	- - -	- - -	- - -
3	- - -	.318/.0220*	.334/.0084	.348/.0158	.341/.0274	1.537/.1259
Adjacent unburned	- - -	.259/.0098	.322/.0056	- - -	- - -	- - -
4	.322/.0165	.259/.0161	.300/.0159	.252/.0102	.297/.0292	1.024/.1758
Adjacent unburned	- - -	- - -	- - -	.266/.0178	.347/.0310	1.006/.1124
5	.327/.0232	.336/.0246	.413/.0223**	.250/.0117	.340/.0381	- - -
Adjacent unburned	- - -	.276/.0158	.304/.0158	.261/.0163	.326/.0153	- - -
6	.384/.0183	- - -	.404/.0349	.304/.0150	.340/.0145	- - -
Adjacent unburned	.372/.0193	- - -	.337/.0176	- - -	.310/.0165	- - -

burning. Higher nutrient availability following prescribed burning (Ryan and Covington, in review) probably explains much of the increase in understory nutrient concentration. However, Christensen (1977) found that not only burning but also clipping unburned plots resulted in increased understory nutrient concentrations in longleaf pine (Pinus palustris Miller). Thus some of the increases in nutrient concentration may be caused by the physical removal of above ground vegetation and the subsequent mobilization of nutrients stored in the root system.

While not conclusive these results suggest that prescribed burning in ponderosa pine increases forage nutrient concentrations for the first year, but that these increases rapidly disappear. The 1 yr surge in nutrients followed by a rapid decline might be attributed to a similar surge in nutrient availability or, if continued high availability occurs, to growth dilution, where increased biomass accumulation outstrips nutrient uptake thereby diluting nutrient concentrations. Whether repeated burning might sustain higher forage nutrient contents in ponderosa pine is unknown but is certainly worthy of study.

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